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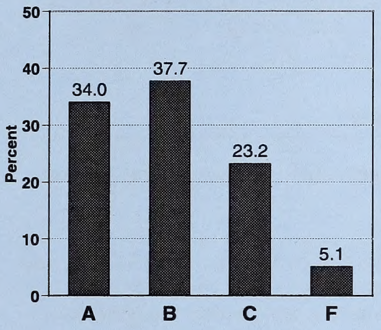
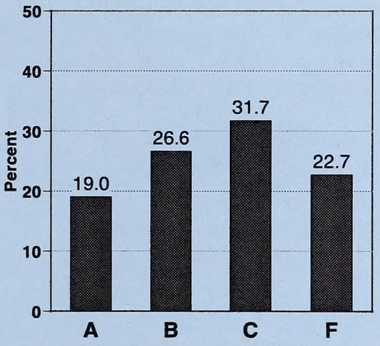
Physics 30

Diploma Examination Results
Examiners' Report for June 1997

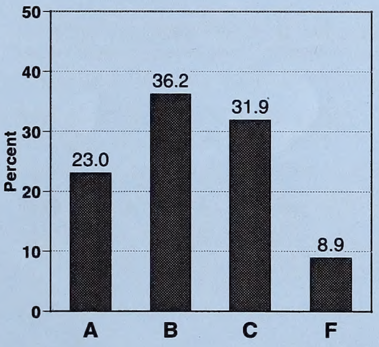
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the June 1997 administration of the Physics 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined January, April, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of 37 multiple-choice questions worth 52.9%, 12 numerical-response questions worth 17.1%, and two written-response questions worth 30% of the total examination.

Achievement of Standards

The information reported is based on the final course marks achieved by 5 128 students in Alberta who wrote the June 1997 examination.

- 91.1% of the 5 128 students achieved the acceptable standard (a final course mark of 50% or higher).
- 23.0% of students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 37.4% of the students who wrote the June 1997 examination were female.

- 92.2% of the female students achieved the acceptable standard (a final course mark of 50% or higher).
- 22.3% of these female students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 62.6% of the students who wrote the June 1997 examination were male.

- 90.5% of the male students achieved the acceptable standard (a final course mark of 50% or higher).
- 23.5% of these male students achieved the standard of excellence (a final course mark of 80% or higher).

Students are demonstrating increased skills in dealing with questions related to the Science, Technology, and Society strand of the curriculum. However, students continue to have difficulty with conservation laws and problems involving multiple steps. This may be a result of students relying on algebraically derived formulas that they have memorized rather than basing their solutions on basic physics principles.

Students First!
Student Evaluation

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 72.1%.
- The average diploma examination mark was 62.7%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.7%.

Approximately 5.0% of the students who wrote the examination in June 1997 and received a school-awarded mark had previously written at least one other Physics 30 Diploma Examination during the June 1996 to June 1997 period. This sub-population (257) achieved an examination average of 55.3%, compared with 63.1% for the population (4 871) who first wrote a Physics 30 examination in June 1997. The group of students who rewrote increased their overall average by 5.7%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the acceptable standard will obtain a mark of 50% or higher, and students achieving the standard of excellence will obtain a mark of 80% or higher.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems
GLE 2	Analyze and predict the behaviour and physical interactions of objects
GLE 3	Describe and analyze resistive circuits and the function of EM devices
GLE 4	Solve problems related to EM wave behaviour and the atomic theory

Skills:

SPSC	Scientific Process Skills and Communication Skills

Science, Technology, Society:

STS	Connections Among Science, Technology, & Society

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
MC1	D	0.825		✓				
MC2	D	0.727		✓				
NR1	8.13*	0.715		✓				
MC3	A	0.531		✓				✓
MC4	A	0.378		✓				✓
MC5	B	0.555		✓				
NR2	1.11	0.675		✓				
NR3	3.75	0.933		✓				
MC6	D	0.465			✓			✓
MC7	D	0.416	✓					
MC8	B	0.861		✓				
MC9	B	0.641		✓				
MC10	A	0.955		✓				✓
NR4	6.60	0.898		✓				✓
MC11	D	0.859			✓		✓	
MC12	C	0.928			✓			✓
MC13	A	0.580			✓			✓

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	SPSC	STS
NR5	8.33	0.756			✓			✓
NR6	3.69	0.665			✓			✓
MC14	D	0.388		✓			✓	✓
MC15	B	0.506		✓			✓	✓
MC16	C	0.363		✓			✓	✓
MC17	A	0.877			✓		✓	✓
MC18	C	0.856			✓		✓	✓
MC19	D	0.858			✓			✓
NR7	1.03	0.682	✓					
MC20	D	0.524	✓					✓
NR8	8.85	0.381				✓		✓
MC21	D	0.768				✓		
NR9	2.75	0.830				✓		
NR10	2025	0.789				✓		
MC22	B	0.804				✓		
MC23	A	0.720	✓				✓	✓
MC24	A	0.604	✓				✓	✓
MC25	C	0.840	✓				✓	✓
NR11	3.84	0.635		✓				✓
MC26	D	0.420	✓					
MC27	C	0.682				✓	✓	
MC28	D	0.485				✓		
MC29	B	0.773				✓		
MC30	A	0.725				✓		✓
MC31	A	0.555				✓	✓	
MC32	C	0.439				✓	✓	
MC33	B	0.670				✓		✓
MC34	B	0.680				✓		✓
MC35	D	0.470				✓		✓
MC36	A	0.768				✓		
NR12	24.6	0.562				✓		✓
MC37	C	0.822				✓		
WR1		0.430	✓				✓	✓
WR2		0.610		✓			✓	

*NR1: 0.13 if A was selected from MC2; 4.00 if B was selected; 4.12 if C was selected; and 8.13 if D was selected.

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine Scored: 32.8 out of 49
Multiple choice: 24.3 out of 37
Numerical response: 8.52 out of 12

Written Response: 11.0 out of 21
Question 1: 4.7 out of 11**
Communication: 1.82 out of 3
Content: 2.9 out of 8
Question 2: 6.1 out of 10

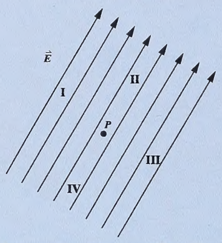
** Individual student scores for Question 1 are equal to the communication score added to the content score, then rounded to a whole number.

General Learner Expectations:

GLE 1	Explain gravitational, electrical, and magnetic effects on systems	9.1	out of	18
GLE 2	Analyze and predict the behaviour and physical interactions of objects	16.7	out of	26
GLE 3	Describe and analyze resistive circuits and the function of EM devices	6.8	out of	9
GLE 4	Solve problems related to EM wave behaviour and the atomic theory	11.2	out of	17
Skills	Scientific process and communication skills	15.7	out of	28
STS	Connections in science, technology, and society	21.7	out of	37

Use the following information to answer the next question.

Electric Field



The parallel arrows represent the direction of an electric field.

7. An electron is placed at point *P*. It will accelerate toward region

A. I
B. II
C. III
***D.** IV

Use the following additional information to answer the next question.

In the ion generation and acceleration chamber, atoms in the sample are ionized by bombarding them with electrons to remove outermost electrons. The biochemist must have the accelerating voltage in the electron gun set high enough to ensure ionization of the particles.

16. Which of the following physical principles must be used to calculate the value of the accelerating voltage in the electron gun?

A. Ohm's law
B. Coulomb's law
***C.** Conservation of energy
D. Conservation of momentum

Numerical Response

8. Northern lights are often observed in Alberta skies. The most common colour, green, has a wavelength of 558 nm. When a collision occurs between energetic electrons and oxygen atoms in the upper atmosphere, the oxygen atoms are excited. To cause the most common colour of northern lights, the electrons must be travelling with a minimum speed, expressed in scientific notation, of $b \times 10^w$ m/s. The value of ***b*** is _________.
(Round and record your answer to three digits.)

Answer: 8.85

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to achieve the acceptable standard and the standard of excellence.

Multiple-choice question 7 Students were asked to apply their knowledge of electric fields in order to determine the direction an electron would move when placed in an electric field. Although most students at the standard of excellence answered correctly by choosing alternative D, the balance of the students found this question very difficult. Both alternatives B and C were selected as the correct response by over 20% of the students. These results, combined with the student responses to written-response question 1, suggest that many students are having a difficult time conceptualizing electric fields and their effects on charged particles.

A total of 41.6% of all students selected the correct answer for this question. Of the students who achieved the standard of excellence, 85.1% answered this question correctly; however, only 37.0% of students who achieved the acceptable standard but not the standard of excellence selected the correct answer.

Multiple-choice question 16 To successfully answer this question, students needed to apply the principle of conservation of energy and recognize that the amount of energy required to ionize the particles must be less than or equal to the kinetic energy of the incoming electrons. In addition, they needed to recall that the accelerating voltage (*V*) required to attain this kinetic energy is given by $V = \frac{E_k}{q}$. Problems involving conservation laws and multiple steps continue to cause difficulties for all but the strongest students. In this question, alternative B was selected by almost as many students as the correct response C. This may be a result of students looking for a force to accelerate the particles.

On this question, 60.9% of the students who achieved the standard of excellence responded correctly, while 25.1% of those achieving the acceptable standard but not the standard of excellence selected the correct response. Of the students who failed to achieve the acceptable standard, only 18.9% responded with the correct answer.

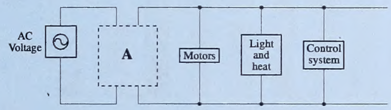
Numerical-response question 8 Students answering this question needed to recognize that sufficient electron kinetic energy must be transferred to the oxygen atoms and that this energy is emitted as green light.

Use the following information to answer the next question.

In many electrically powered passenger trains, the input voltage V_i from the power supply is not the same as the operating voltage V_0 of the electrical circuitry of the train.

Examples:	V_i	V_0
England	750	1 500
English Channel	25 000	1 500
Belgium	3 000	1 500
France	50 000	1 500

The diagram below is a partial schematic of the electrical circuitry of an electric train.



19. The component labelled A in the diagram is **most likely** a

A. battery
B. resistor
C. generator
***D.** transformer

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30. A burglar knows that an alarm in a certain museum makes use of the photoelectric effect. Ultraviolet light shines on a photocell with a work function of 5.01 eV. Any break in the light will set the alarm off. The burglar realizes that if he shines his own ultraviolet light source at the photocell, he can ensure that there is no break in the light and that the alarm will not be set off. He obtains an ultraviolet light source with a frequency of 1.13×10^{15} Hz. Will he be successful in his burglary attempt and why?

***A.** No, because the frequency of the burglar's light is too low for the photocell to function.
B. No, because the frequency of the burglar's light is too high for the photocell to function.
C. Yes, because the frequency of the burglar's light is low enough for the photocell to function.
D. Yes, because the frequency of the burglar's light is high enough for the photocell to function.

They then had to calculate the energy of the emitted light that corresponds to the minimum electron kinetic energy. Once again, the requirement to use energy conservation and multiple steps made this question difficult for most students. Overall, only 38.1% of students answered this question correctly. It is interesting to note that 21.2% of students recorded an answer of 3.00 to this question, a response that suggests they believed the electrons were travelling at the speed of light.

On this question, 77.4% of the students who achieved the standard of excellence calculated the correct response. Of the students who achieved the acceptable standard but not the standard of excellence, 37.0% answered correctly. Only 8.0% of the students who failed to achieve the acceptable standard were able to calculate the correct answer.

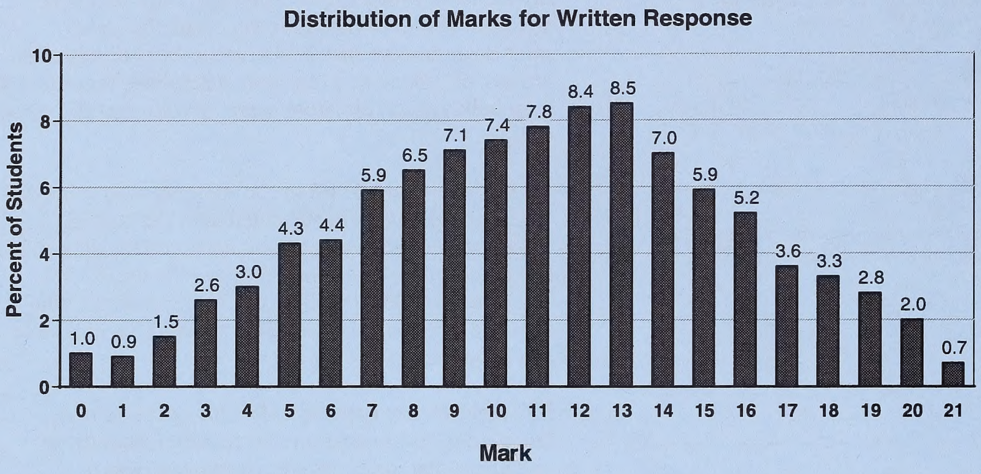
Multiple-choice question 19 This question is a knowledge-level question that required students to recognize that the necessary component was a transformer. Overall, 85.8% of students selected the correct response. Of the students who achieved the standard of excellence, 98.8% answered correctly, and of those who achieved the acceptable standard but not the standard of excellence, 90.2% were correct in their response. In addition, 63.6% of students who did not achieve the acceptable standard chose the correct answer.

Multiple-choice question 30 This question required the students to calculate the frequency of the ultraviolet light the burglar was using and to realize that since it was below the threshold frequency of the photocell, it would not cause photons to be emitted. This question distinguished well between students at different levels.

Of the students who achieved the standard of excellence, 94.3% answered this question correctly, while 75.8% of those achieving the acceptable standard but not the standard of excellence were able to successfully answer the question. Of students who did not achieve the acceptable standard, only 45.9% chose the correct answer.

Written-Response Questions

Of all the students who wrote the exam, 55.4% received a mark of 11 or higher out of 21. The average mark on the written-response questions was 11.0, or 52.4%.



Written Response – 11 marks

1. An astronaut has just landed on an unknown, uninhabited planet and has to send some information about the planet back to Earth. Assume the astronaut has all of the equipment needed to perform the necessary experiments.

Using physics concepts as well as any related formulas, describe procedures that could be used in order to:

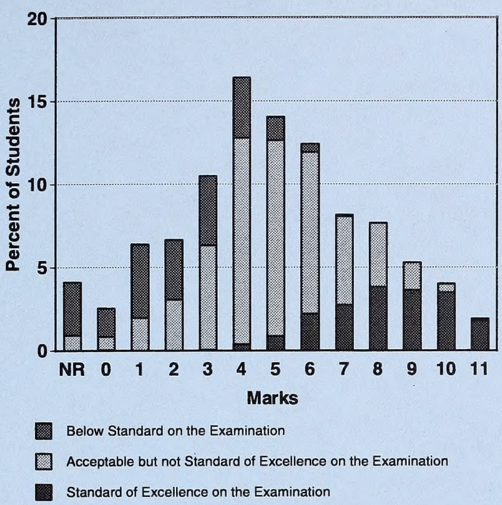
- **measure** the magnitude and direction of the gravitational field at the astronaut's location on the unknown planet
- determine whether or not there is an electric field at the location and, if there is, to determine its **magnitude** and **direction**
- determine whether or not there is a magnetic field at the location and, if there is, to determine its **direction**

Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

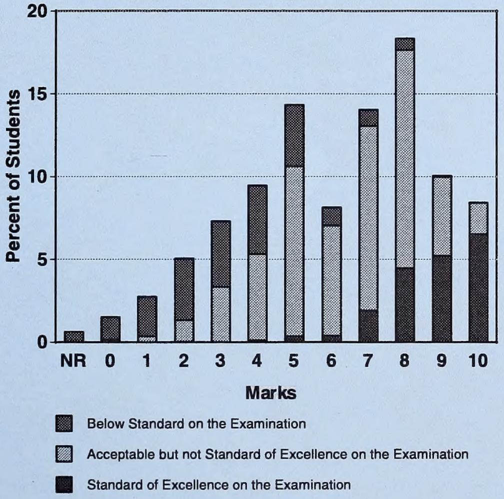
Written-response question 1 was not as well answered as expected. This question had an average of 4.7 out of 11, or 42.7%. To obtain full marks for this question, students needed to correctly complete all five components of the question; i.e., describe methods to measure gravitational and electric field strengths, and describe methods to determine the directions of the gravitational, electric, and magnetic fields. Students used a wide variety of methods to measure field strength and were awarded marks if they provided a reasonable experimental design or selected an appropriate formula and described how they would make the required measurement. Marks were awarded for determining field directions if the students described an appropriate experiment to determine field directions, or if they provided a definition of how field directions could be determined.

In general, students did a good job of describing a method to measure gravitational field strength by using kinematics, energy conservation, or a pendulum. Many students successfully determined magnetic field direction by describing how a compass would respond in the presence of a magnetic field. In addition, those students who used a Millikan-like experiment to balance forces showed a good understanding of how electric field strength

Distribution of Marks for Question 1



Distribution of Marks for Question 2



could be measured. Many students went beyond the scope of the question and attempted to describe methods for measuring magnetic field strength. In many cases, students looked for highly technological solutions and overlooked the simplest solutions for determining field strengths and directions.

Describing a method to measure electric field strength was, in general, not done well. Students' solutions revealed several misconceptions about electric fields. Student's errors included:

- not making the distinction between forces and fields
- using inappropriate values in the formula $\bar{E} = \frac{kq_1}{r^2}$
- using hand rules for electric field direction
- assuming that the presence of a magnetic field automatically implies the presence of a perpendicular electric field
- assuming that an electric field causes a charged particle to move in a circle
- assuming that an electric field can be detected by a compass

Despite the open-ended nature of this question, only 4.1% of students did not respond to it.

In general, student responses were well organized, and students were able to clearly communicate their ideas. The average mark for communication was 1.82 out of 3.

Of the students who achieved the standard of excellence on the exam, 46.9% received 9 out of 11 or better on this question.

On this question, 36.3% of the students who achieved the acceptable standard but not the standard of excellence received 6 out of 11 or better.

In **written-response question 2** (see next page), parts a, b, c, and e were well answered. Students were able to indicate the final direction of the balls after collision, calculate their final speed, and calculate the angle between their final positions. Most students were also able to correctly calculate the kinetic energy lost as a result of the collision. The most common errors in these sections included not labelling the diagram, significant digit errors, and not explicitly stating the formulas being used to solve the problem.

In order to solve part d correctly, students needed to state and show that momentum in the *x* direction and momentum in the *y* direction were the same before and after collision. This could be done by considering the components separately or by using a vector diagram.

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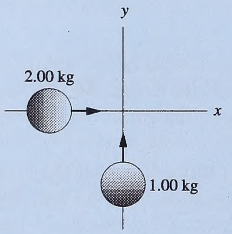
Use the following information to answer written-response question 2.

Computer-Generated Data

time (s)	2.00 kg p_x kg•m/s	p_y kg•m/s	$\lvert\bar{p}\rvert$ kg•m/s	1.00 kg p_x kg•m/s	p_y kg•m/s	$\lvert\bar{p}\rvert$ kg•m/s
0.000	18.0	0.00	18.0	0.00	4.00	4.00
0.020	18.0	0.00	18.0	0.00	4.00	4.00
0.040	18.0	0.00	18.0	0.00	4.00	4.00
0.060	18.0	0.00	18.0	0.00	4.00	4.00
0.080	18.0	0.00	18.0	0.00	4.00	4.00
0.100	18.0	0.00	18.0	0.00	4.00	4.00
0.120	18.0	0.00	18.0	0.00	4.00	4.00
0.140	18.0	0.00	18.0	0.00	4.00	4.00
0.160	18.0	0.00	18.0	0.00	4.00	4.00
0.180	12.5	7.31	14.5	5.48	–3.31	6.41
0.200	12.5	7.32	14.5	5.47	–3.32	6.40
0.220	12.5	7.32	14.5	5.47	–3.32	6.40
0.240	12.5	7.32	14.5	5.47	–3.32	6.40
0.260	12.5	7.32	14.5	5.47	–3.32	6.40
0.280	12.5	7.32	14.5	5.47	–3.32	6.40
0.300	12.5	7.32	14.5	5.47	–3.32	6.40
0.320	12.5	7.32	14.5	5.47	–3.32	6.40
0.340	12.5	7.32	14.5	5.47	–3.32	6.40
0.360	12.5	7.32	14.5	5.47	–3.32	6.40
0.380	12.5	7.32	14.5	5.47	–3.32	6.40
0.400	12.5	7.32	14.5	5.47	–3.32	6.40

Note: p_x and p_y are the x and y components of a momentum vector $\bar{p}$.

Two Dimensional Collision



Written Response – 10 marks

2. A 2.00 kg ball and a 1.00 kg ball collide. Their original directions of motion are as indicated in the diagram. A computer program that simulates this collision generated the data on the previous page.

   a. Indicate **on the diagram** the approximate direction of motion for each ball after collision.

   b. Determine the speed of each ball before **and** after the collision.

   c. Determine the angle between the balls **after** the collision.

   d. Show that the total momentum before the collision is equal to the total momentum after the collision.

   e. How much kinetic energy is lost as a result of this collision?

Many students who failed to answer part d correctly attempted to use a linear solution for conservation of momentum. Students must learn to recognize two-dimensional momentum problems and use appropriate methods in their solutions.

When two-dimensional solutions were attempted, some students experienced difficulty drawing complete vector diagrams. Often the magnitudes were compared, but the directions of the resultants were not calculated and compared.

On this question, 85.4% of the students who achieved the standard of excellence on the exam received 8 out of 10 or better.

Of the students who achieved the acceptable standard but not the standard of excellence, 82.1% scored 5 out of 10 or better on this question. Less than 1% of students did not attempt this question.

For further information, contact Corinne McCabe (cmccabe@edc.gov.ab.ca) or Phill Campbell (pcampbell@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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